THE DRIFT OF METEOR TRAILS

V. P. Tsesevich
Submitted 6 Jul 1950

In 1933, the author accidentally discovered during observations on a variable star that trails are left after some meteors which are not visible to the naked eye, but can be seen only with binoculars or a telescope. Systematic study of this interesting effect was begun at this time. Observers began to scan the region of the sky close to the end of the meteor arc in order to find a "stable" trail. After the trail was found, its positions at various times were plotted on a map of the stellar sky. Strong prismatic binoculars or telescopes were used in the observations.

The slow displacement of the meteor trail is called the drift. Instructions for fulfilling such observations were written by the author and, starting in 1934, these observations were made regularly for a number of years at the Tadzhik Astronomical Observatory, especially when meteor showers were maximum. The instructions were later published (V. P. Tsesevich, Byull. Vsesoyuzn. Astr. Geodez. Ob-va, No 5, 1940).

The observations gathered were processed by V. V. Fedynskiy (V. V. Fedynskiy, Astr. Zhur., Vol XXI, No 6, 1944), who determined the speed of displacement of air masses in the stratosphere from the apparent movement of the meteor trail. He obtained stratospheric wind roses, which did not however reveal any clear regularities. Similar works were published later by other researchers.

Fedynskiy devised a method for processing observations and calculating the drift speeds. Since it has been established that meteor trails emerge in the ionosphere and apparently are the result of excitation of atoms or molecules at heights around 90-100 kilometers, Fedynskiy assumed that the trails move only horizontally (i.e., that their height above sea level does not change).

CONFIDENTIAL

CONFIDENTIAL

50X1-HUM

The method and formulas for the calculations are as follows: We assume that, at two definite times t_1 and t_2, the horizontal coordinates of the same point of the meteor trail a_1, z_1 and a_2, z_2 are determined. Then, if we assume that the trail height is constant at $H = 83,000$ m, we obtain the following formulas for the rectangular coordinates of the track:

$$x_1 = H \cdot \tan z_1 \cdot \cos a_1; \quad x_2 = H \cdot \tan z_2 \cdot \cos a_2; \quad y_1 = H \cdot \tan z_1 \sin a_1;$$

$$y_2 = H \cdot \tan z_2 \sin a_2.$$

The OX-axis is directed to the south, and the OY-axis to the west. The drift speed is calculated from the formulas

$$v_x = \frac{x_2 - x_1}{t_2 - t_1}; \qquad v_y = \frac{y_2 - y_1}{t_2 - t_1}.$$

These formulas have been used for all drift speeds calculated up to the present time. This solution of the problem has one major error, however, which is unavoidable in one-point observations. The meteor trail actually drifts not only horizontally, but vertically as well. As will be shown in this work, the use of Fedynskiy's method often leads to results which have nothing in common with reality.

In the summer of 1948, a meteor station was organized near Odessa for one week during a Perseid shower, and observations were conducted simultaneously from two points. Eleven meteor trails were observed, one of which was most carefully plotted on maps and was observed simultaneously from two points.

The coordinates of the observation points were points A and B:

A: long = $2^h 3^m 2.2^s$,   lat = $46° 28' 36"$

B: "   " $2^h 2^m 47.2^s$,   "   " $46° 21' 42"$

The two points are 13.63 air kilometers apart. This meteor appeared on 12 August 1948, $21^h 28^m 46^s$ GCT. The plotting was done by Ye. N. Kramer at point A on Bonn Observatory charts and by the author at point B on the large Mikhaylov atlas. Data on the trail of this meteor is shown in Table 1.

Table 1

	A	B
Right ascension of point of appearance	$0^h 54.1^m$	$1^h 8.0^m$
Declination of point of appearance	$+20° 16'$	$+23° 11'$
Right ascension of point of disappearance	$0^h 50.0^m$	$1^h 6.0^m$
Declination of point of disappearance	$+17° 41'$	$+21° 49'$
Sidereal time of appearance	$20^h 56^m 49^s$	
Sidereal time of disappearance	$20^h 58^m 31^s$	
Zenith distance of point of appearance	$54° 27'$	$54° 54'$
Azimuth of point of appearance	$-82° 24'$	$-87° 44'$
Zenith distance of point of disappearance	$55° 15'$	$55° 11'$
Azimuth of point of disappearance	$-78° 51'$	$-85° 47'$

- 2 -

CONFIDENTIAL

CONFIDENTIAL

We cite the results of calculations of the rectangular coordinates of the points of appearance and disappearance of the trail. The coordinate axes are oriented the same as before, i.e., OX to the south, OY to the west, and the new OZ axis is directed upward. We disregarded the earth's curvature in the derivation. The origin is situated in Odessa, in the astronomical observatory.

The point of appearance is characterized by the coordinates:

$$x_1 = +20.1 \text{ km}; \quad y_1 = -148.4 \text{ km}; \quad \text{and } z_1 = +107.0 \text{ km}.$$

The point of disappearance (extinction) of the trail is characterized by the coordinates:

$$x_2 = +25.4 \text{ km}; \quad y_2 = -129.0 \text{ km}; \quad \text{and } z_2 = +91.2 \text{ km}.$$

Dividing the difference in coordinates by the time of drift, equal to 102 seconds, we find:

$$v_x = +53 \text{ m/sec}; \quad v_y = +190 \text{ m/sec}; \quad \text{and } v_z = -155 \text{ m/sec}.$$

If we assume that this meteor originated in the radiant point of the Perseids (which corresponds to observations), the angle which the drift made with the flight direction was $37°$.

The figures cited show that the meteor trail also moves downward. The conclusion relative to horizontal movement of trails was based on observations of those meteors which leave long-lasting trails after them. The rapidly disappearing "stable" trail and the long-lasting meteor trail are two different phenomena. The latter drift in a calm atmosphere, while the rapidly disappearing trails drift in an atmosphere excited by the rapid flight of cosmic particles.

To evaluate the distortion which is caused by assuming horizontal movement of the trail, we calculated the drift velocity considering both observations to be independent one-point observations and obtained these results:

From observations at point A: $v_x = +74 \text{ m/sec}; \quad v_y = -22 \text{ m/sec},$

From observations at point B: $v_x = +40 \text{ m/sec}; \quad v_y = -10 \text{ m/sec}.$

It is quite obvious that the components v_y, giving an average of about -16 m/sec, are very different from the actual value of $+190 \text{ m/sec}$. Thus, the vertical drift components, which are not determined in one-point observations, make the results worthless.

Kramer's observations at point A were made especially carefully, therefore, one can, by considering the trail drift to be rectilinear, calculate its entire path in the atmosphere. This is shown in Table 2. The results are particularly reliable because the trail was quickly transformed into a small cloud and therefore its movement could be easily traced.

Table 2

Trail Pt	x	y	z	r, km	t, sec	v, m/sec
a	+ 20.1	-148.4	+107.0	0.0	42	305
b	+ 22.8	-138.7	+ 99.1	12.8	19	360
c	+ 24.2	-133.5	+ 94.9	19.6	9	310
d	+ 24.7	-131.4	+ 93.2	22.4	--	--
e	+ 25.4	-129.0	+ 91.2	25.6	--	--

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

CONFIDENTIAL

50X1-HUM

In Table 2, a, b, c, d, and e correspond to the different positions occupied by the trail at various times; a is the beginning of the phenomena, b is the end, r is the distance from the beginning along the trail, x, y, and z are the rectangular coordinates of the points, t is the time elapsed between neighboring positions of the trail, and v is the average speed for the time elapsed between two neighboring positions. The table shows that the average speed was approximately constant during the entire drift (about 320 m/sec).

The general conclusions from the observations of this extremely interesting effect are these: (1) one-point observations of the drift of meteor trails cannot be processed without additional hypotheses and cannot give reliable results; (2) meteor trails drift not only laterally, but also downward, and with a speed which cannot be disregarded; (3) further observations should be made simultaneously from at least two points not less than 15 km apart; the observations should be made with strong binoculars or a telescope; both points should be connected by telephone; (4) the author proposes that the drift of a rapidly disappearing meteor trail is not caused by real movements in an undisturbed stratosphere, but by electromagnetic effects connected with the movement of charged particles in the earth's magnetic field. This proposition demands further regular observations and theoretical discussion of their results.

- E N D -

CONFIDENTIAL

CONFIDENTIAL